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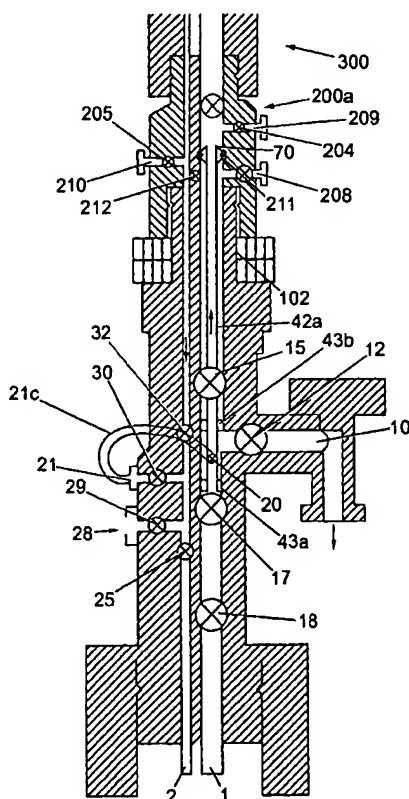
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0027269.0 8 November 2000 (08.11.2000) GB</p> <p>(71) Applicant and</p> <p>(72) Inventor: DONALD, Ian [GB/GB]; Ramstone Millhouse, Money musk, Aberdeenshire AB51 7TS (GB).</p> <p>(74) Agent: MURGITROYD & COMPANY; 373 Scotland Street, Glasgow G5 8QA (GB).</p> | <p>(81) Designated States (<i>national</i>): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.</p> <p>(84) Designated States (<i>regional</i>): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published:
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- (54) Title:** RECOVERY OF PRODUCTION FLUIDS FROM AN OIL OR GAS WELL



(57) Abstract: A flow diverter assembly for a tree, the flow diverter assembly having a flow diverter to divert fluids flowing through the production bore of the tree from a first portion of the production bore to the cap, and to the divert the fluids back from the cap to a second portion of the production bore for recovery therefrom via an outlet, wherein the flow diverter is detachable from the cap to enable insertion of the flow diverter through the cap.

WO 02/38912 A1



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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

1 "Recovery of production fluids from an oil or gas
2 well"

3

4 The present invention relates to the recovery of
5 production fluids from an oil or gas well having a
6 christmas tree.

7

8 Christmas trees are well known in the art of oil and
9 gas wells, and generally comprise an assembly of
10 pipes, valves and fittings installed in a wellhead
11 after completion of drilling and installation of the
12 production tubing to control the flow of oil and gas
13 from the well. Subsea christmas trees typically
14 have at least two bores one of which communicates
15 with the production tubing (the production bore),
16 and the other of which communicates with the annulus
17 (the annulus bore). The annulus bore and production
18 bore are typically side by side, but various
19 different designs of christmas tree have different
20 configurations (i.e. concentric bores, side by side
21 bores, and more than two bores etc).
22 Typical designs of christmas tree have a side outlet
23 to the production bore closed by a production wing

1 valve for removal of production fluids from the
2 production bore. The top of the production bore and
3 the top of the annulus bore are usually capped by a
4 christmas tree cap which typically seals off the
5 various bores in the christmas tree.

6

7 Mature sub-sea oil wells producing at high water-
8 cuts often lack the necessary pressure drive to flow
9 at economic rates and are often hampered by the
10 back-pressure exerted on them by the processing
11 facilities. Several means of artificial lift are
12 available to boost production rates, but they either
13 involve a well intervention or modification to the
14 sea bed facilities, both of which are expensive
15 options and may be sub-economic for sub sea wells
16 late in the life cycle with limited remaining
17 reserves.

18

19 PCT/GB00/01785 (which is hereby incorporated by
20 reference) describes a method of recovering
21 production fluids from a well having a tree having a
22 first flowpath and a second flowpath, the method
23 comprising diverting fluids from a first portion of
24 the first flowpath to the second flowpath, and
25 diverting the fluids from the second flowpath back
26 to a second portion of the first flowpath, and
27 thereafter recovering fluids from the outlet of the
28 first flowpath, and typically uses a tree cap to
29 seal off the production and annulus bores, and to
30 divert the fluids.

31

1 The present invention provides a flow diverter
2 assembly for a tree, the flow diverter assembly
3 having a flow diverter to divert fluids flowing
4 through the production bore of the tree from a first
5 portion of the production bore to the cap, and to
6 divert the fluids back from the cap to a second
7 portion of the production bore for recovery
8 therefrom via an outlet, wherein the flow diverter
9 is detachable from the cap to enable insertion of
10 the flow diverter through the cap.

11

12 The tree is typically a subsea tree (such as a
13 christmas tree) on a subsea well.

14

15 The diverter assembly typically includes the cap.
16 The diverter can be locked to the cap by a locking
17 means.

18

19 Typically, the diverter assembly can be formed from
20 high-grade steels or other metals, using e.g.
21 resilient or inflatable sealing means as required.

22

23 The diverter may include outlets for diversion of
24 the fluids to a pump or treatment assembly remote
25 from the cap.

26

27 The flow diverter preferably comprises a conduit
28 capable of insertion into the production bore, the
29 assembly having sealing means capable of sealing the
30 conduit against the wall of the production bore.

31 The conduit may provide a flow diverter through its
32 central bore which typically leads to a tree cap and

1 the pump mentioned previously. The seal effected
2 between the conduit and the production bore prevents
3 fluid from the first portion of the production bore
4 entering the annulus between the conduit and the
5 production bore except as described hereinafter.
6 After passing through a typical booster pump,
7 squeeze or scale chemical treatment apparatus, the
8 fluid is diverted into the second portion of the
9 production bore and from there to the production
10 bore outlet.

11

12 Optionally the fluid may be diverted through a
13 crossover back to the production bore and then onto
14 the production bore outlet.

15

16 The pump can be powered by high-pressure water or by
17 electricity, which can be supplied direct from a
18 fixed or floating offshore installation, or from a
19 tethered buoy arrangement, or by high-pressure gas
20 from a local source.

21

22 The cap preferably seals within christmas tree bores
23 above an upper master valve. Seals between the cap
24 and bores of the tree are optionally O-ring,
25 inflatable, or preferably metal-to-metal seals. The
26 apparatus can be retrofitted very cost effectively
27 with no disruption to existing pipework and minimal
28 impact on control systems already in place.
29 Preferably the cap includes equivalent hydraulic
30 fluid conduits for control of tree valves, and which
31 match and co-operate with the conduits or other

1 control elements of the tree to which the cap is
2 being fitted.

3

4 The typical design of the flow diverter within the
5 cap can vary with the design of tree, the number,
6 size, and configuration of the diverter channels
7 being matched with the production and annulus bores,
8 and others as the case may be. Preferably the
9 diverters in the cap comprise a number of valves to
10 control the inflow and outflow of fluids therefrom.
11 This provides a way to isolate the pump from the
12 production bore if needed, and also provides a
13 bypass loop.

14

15 Certain embodiments of the apparatus can typically
16 comprise a conduit that seals within the tree bore
17 above the upper master valve and diverts flow to a
18 remote device for pressure boosting or flow testing.
19 Having flow tested or pressure boosted the produced
20 fluids, the fluids are connected to the annular
21 space between the flow diverter and the original
22 tree bore or the tree crossover pipework/annulus
23 bore, into the existing flowline via the existing
24 wing valve. The concept allows the device to be
25 installed/retro fitted very cost-effectively with no
26 disruption to existing pipework and minimal impact
27 on control systems.

28

29 Certain embodiments of the diverter allow insertion
30 through the tree cap after the cap is attached to
31 the tree, and may withdrawn through the cap without
32 detaching the cap from the tree.

1 Typically the cap is deployed as part of the
2 standard drilling stack. Typically the conduit is
3 fitted to the cap after installation of the cap
4 along with a lower riser package and can use the
5 hydraulic functionality of the existing tree cap to
6 enable additional valves to be controlled, and
7 provides a means to isolate the pump from the
8 production bore, if required. However, certain
9 embodiments of the invention can be deployed without
10 MODU, DSV, or RSV support, can simply be operated
11 from a local tool placed on or near to the tree cap.
12

13 The invention also provides a method of installing a
14 flow diverter on a tree, the method comprising
15 attaching a cap to the tree, and installing the
16 diverter through the cap after the cap has been
17 attached to the tree.
18

19 The diverter can be carried by the cap (for example
20 on the outboard end of the cap) while the inboard
21 end of the cap is being attached to the tree, or can
22 be conveyed from a remote position (e.g. the
23 surface) after the cap has been attached to the
24 tree.
25

26 The conduit is typically attached to the cap, held
27 within the production bore of the tree and sealed
28 therein thus enabling flow to be diverted through
29 the bore of the insert to the cap and thereafter to
30 the surface for testing or pumping then re-injected
31 via the riser annulus or the external flowline
32 through the annulus between the production bore and

1 conduit and into the production pipeline or
2 flowline. Alternatively the fluid may be re-
3 injected into the tree via an annulus or other bore
4 of the tree after treatment, and from there diverted
5 via a crossover to the first flowpath and the
6 outlet.

7

8 The flow diverter assembly can be used as part of
9 the drilling riser package to enable flow to be
10 directed through the surface test package, either
11 choke manifold or multiphase meter, and then into
12 the flowline via the tree.

13

14 The cap is typically installed on top of the tree
15 and below the Lower Riser Package or the Subsea test
16 tree, dependent on the tree configuration, or as
17 extended tubing from the surface at the surface tree
18 or on coiled tubing or wireline or seal directly
19 against the bore of diverter unit.

20

21 The cap typically comprises a connector to interface
22 with the tree, internal valving and flow paths.

23

24 The upper end of the conduit may be sealed against
25 the LRP bore at the LRP XOY valve to provide the
26 same function. The upper end of the conduit may be
27 sealed against the surface tree bore to provide the
28 same functionality.

29

30 In well test applications, the method enables the
31 produced fluids to be well tested at surface and re-
32 injected into the flowline thus potentially

1 eliminating well flaring and enabling extended well
2 testing.

3

4 Following well tests the cap and diverting means can
5 be left in place and connected to a pumping package
6 for pressure boosting if required.

7

8 With an MODU, installation of the diverter may be
9 achieved without retrieving and re-running the
10 drilling stack to seabed. With a DSV, the insert
11 removes the need for storage, which brings realistic
12 well testing objectives within the capabilities of a
13 suitably equipped mono hull.

14

15 The assembly and method are typically suited for
16 subsea production wells in normal mode or during
17 well testing, but can also be used in subsea water
18 injection wells, land based oil production injection
19 wells, and geothermal wells.

20

21 The present invention also provides a method of
22 recovering production fluids from a well having a
23 tree, the tree having a first flowpath and a second
24 flowpath, the method comprising diverting fluids
25 from a first portion of the first flowpath to the
26 second flowpath, and diverting the fluids from the
27 second flowpath back to a second portion of the
28 first flowpath, and thereafter recovering fluids
29 from the outlet of the first flowpath, wherein the
30 fluids are diverted from the wellhead to a remote
31 location, and are returned to the wellhead from the

1 remote location for diversion into the outlet of the
2 first flowpath.

3

4 Preferably the first flowpath is a production bore,
5 and the first portion of it is typically a lower
6 part near to the wellhead. The second portion of
7 the first flowpath is typically an upper portion of
8 the bore adjacent a branch outlet, although the
9 second portion can be in the branch or outlet of the
10 first flowpath.

11

12 The diversion of fluids from the first flowpath
13 allows the treatment of the fluids (e.g. with
14 chemicals) or pressure boosting for more efficient
15 recovery before re-entry into the first flowpath.

16

17 Optionally the second flowpath is an annulus bore of
18 the tree, or an annulus between a conduit inserted
19 into the first flowpath, and the bore of the first
20 flowpath. Other types of bore may optionally be
21 used for the second flowpath instead of an annulus
22 bore.

23

24 Typically the flow diversion from the first flowpath
25 to the second flowpath is achieved by a cap on the
26 tree. Optionally, the cap contains a pump or
27 treatment apparatus, but this can preferably be
28 provided separately, or in another part of the
29 apparatus, and in most embodiments, flow will be
30 diverted via the cap to a remote pump etc and
31 returned to the cap by way of tubing.

32

1 According to a further aspect of the present
2 invention there is provided a method for recovering
3 fluids from a well having a tree, the tree having a
4 cap and a first flowpath and a second flowpath, the
5 method comprising attaching the cap to the tree,
6 inserting a fluid diverter to divert fluids from a
7 bore of the tree to a second flowpath, diverting
8 fluids from the second flowpath back to a second
9 portion of the bore, and thereafter recovering
10 fluids from the outlet of the bore wherein the first
11 or second flowpath is attached to or detached from
12 the cap without detaching the cap from the tree.

13

14 Typically the method includes the step of
15 withdrawing a plug from the bore (e.g. the
16 production bore of the tree) after the cap has been
17 attached, and thereafter inserting the fluid
18 diverter into the production bore of the tree,
19 typically through the cap.

20

21 Preferably the diverter comprises a tubular or other
22 conduit inserted into the production bore. The
23 second flowpath can comprise the bore of the tubular
24 or other conduit. Alternatively the second flowpath
25 may comprise the annulus between the tubular or
26 conduit and a bore (e.g. the production bore) of the
27 tree.

28

29 Typically the cap is provided to hold the tubular or
30 other conduit in place. Typically the cap has a
31 through-bore. Optionally the through-bore of the cap
32 has wireline grooves that can engage the conduit, in

1. order to hold it in place in the first flowpath.
2. Alternatively the cap and conduit may engage by
3. other means e.g. resilient teeth, thread etc.
4. Typically the cap is attached to the top of the tree
5. and is inserted as part of the drilling stack (which
6. connects the tree to the surface vessel). The first
7. flowpath is then free from obstructions, and plugs
8. (which are commonly inserted downhole above the
9. production bore outlet before production is
10. commenced) may then be removed. The bore is then
11. typically filled with dense fluid and optionally
12. pressurised in order to prevent well blow out. The
13. conduit is then typically lowered on a line (e.g.
14. wireline) down the drilling stack into the cap,
15. which engages the conduit by the wireline grooves or
16. threads, or by other engaging means as provided.
17. The conduit is then held within the first flowpath.
18.
19. The conduit typically has a second sealing means,
20. which seals the conduit to the production bore and
21. diverts fluids from a first portion of the
22. production bore into the bore of the second
23. flowpath, normally the annulus.
24.
25. Embodiments of the invention allow for production
26. fluid or water injection boosting, subsea metering,
27. chemical injection, and extended well test re-
28. injection. For example, in certain embodiments used
29. in a water injection tree, the flow of fluids
30. through the production conduits can be reversed,
31. with water being injected back through the
32. production wing, through the insert and the cap, and

1 into the production bore to pressurise the
2 reservoir.

3

4 Embodiments of the invention will now be described
5 by way of example only with reference to the
6 accompanying drawings in which:

7

8 Fig. 1 is a side sectional view of a typical
9 production tree;

10 Fig. 2a is a side view of the Fig. 1 tree with
11 a cap in place;

12 Fig. 2b is a diagram of the valve
13 interconnections of the Fig. 2a embodiment
14 during drilling mode;

15 Fig. 3a is a view of the Fig. 1 tree with the
16 cap and a conduit in place;

17 Fig. 3b is a diagram of the valve
18 interconnections of the Fig. 3a embodiment
19 during drilling mode;

20 Fig. 3c is a diagram of the valve
21 interconnections of the Fig. 3 embodiment in
22 flow injection mode;

23 Fig. 4 is a side sectional view of a further
24 embodiment with the cap and a conduit in place;

25 Fig. 5a is a side sectional view of a further
26 embodiment with the cap and a straddle in
27 place; and,

28 Fig. 5b is a diagram of the valve
29 interconnections of the Fig. 5a embodiment
30 during drilling mode;

31 Fig. 6 is a side sectional view of a further
32 tree with the cap and conduit in place;

1 Fig. 7 is a side sectional view of a
2 conventional horizontal tree; and
3 Fig. 8 is a side sectional view of the Fig. 7
4 embodiment with a further embodiment of a cap
5 installed.

6
7 Referring now to the drawings, a typical production
8 tree 100 on an offshore oil or gas wellhead
9 comprises a production bore 1 leading from
10 production tubing (not shown) and carrying
11 production fluids from a perforated region of the
12 production casing in a reservoir (not shown). An
13 annulus bore 2 leads to the annulus between the
14 casing and the production tubing and a christmas
15 tree seal or cap 4 which seals off the production
16 and annulus bores 1, 2, and provides a number of
17 hydraulic control channels 3 by which a remote
18 platform or intervention vessel can communicate with
19 and operate the valves in the christmas tree. The
20 cap 4 is removable from the christmas tree in order
21 to expose the production and annulus bores in the
22 event that intervention is required and tools need
23 to be inserted into the production or annulus bores
24 1, 2.

25
26 The flow of fluids through the production and
27 annulus bores is governed by various valves shown in
28 the typical tree of Fig. 1. The production bore 1
29 has a branch 10 that is closed by a production wing
30 valve (PWV) 12. A production swab valve (PSV) 15
31 closes the production bore 1 above the branch 10 and
32 PWV 12. Two lower production master valves UPMV 17

1 and LPMV 18 (LMPV 18 is optional) close the
2 production bore 1 below the branch 10 and PWV 12.
3 Between UPMV 17 and PSV 15, a crossover port (XOV)
4 20 is provided in the production bore 1 which
5 connects to a crossover port (XOV) 21 in annulus
6 bore 2.
7
8 The annulus bore 2 is closed by an annulus master
9 valve (AMV) 25 below an annulus outlet 28 controlled
10 by an annulus wing valve (AWV) 29 below crossover
11 port 21. The crossover port 21 is closed by
12 crossover valve 30. An annulus swab valve 32
13 located above the crossover port 21 closes the upper
14 end of the annulus bore 2.
15 All valves in the tree are typically hydraulically
16 controlled (with the exception of LPMV 18 which may
17 be mechanically controlled) by means of hydraulic
18 control channels 3 passing through the seal 4 and
19 the body of the tool or via hoses as required, in
20 response to signals generated from the surface or
21 from an intervention vessel.
22
23 When production fluids are to be recovered from the
24 production bore 1, LPMV 18 and UPMV 17 are opened,
25 PSV 15 is closed, and PWV 12 is opened to open the
26 branch 10 which leads to the pipeline (not shown).
27 PSV 15 and ASV 32 are only opened if intervention is
28 required.
29
30 Referring now to Fig. 2, a cap 200 is mounted onto
31 the typical production tree 100 along with the lower
32 riser package and emergency disconnect package

1 (LRP/EDP) 300. The cap 200 and LRP/EDP 300 connect
2 to the tree 100 by means of a box and pin
3 connection, as standard in the industry. The
4 production bore 1 and annulus bore 2 of the tree are
5 aligned with the corresponding bores of the cap 200
6 and LRP/EDP 300.

7
8 Branches 208, 209 extend from a production bore 201
9 of the cap 200, each provided with a wing valve 203,
10 204 respectively. A similar branch 210 is connected
11 to an annulus bore 202 of the cap 200 having a valve
12 205. A valve 207 is provided in the production bore
13 201 above the branches 208, 209. A further valve
14 212 connects the production 201 and annulus 202
15 bores of the cap 200. Wireline grooves 211 are
16 provided on the inside of the production bore 201 of
17 the cap 200 between the ports 208, 209.

18
19 Typically a metal seal (not shown) is provided in
20 the production bore 1 below the LPMV valve 18 to
21 prevent the escape of fluids when the system is not
22 in use, for example, due to extreme weather
23 conditions or immediately after construction of the
24 tree system 100.

25
26 A separate detachable insert or conduit 42 is
27 inserted into the production bore 1 (Fig. 3) through
28 the cap 200 and attached at its upper end to the cap
29 200 by means of the wireline grooves 211 on the cap
30 200. The insert 42 is attached to the inner surface
31 of the production bore 1 at its lower end by
32 inflatable or resilient seals 43 which can seal the

1 outside of the conduit 42 against the inside walls
2 of the production bore 1 to divert production fluids
3 flowing up the production bore 1 in the direction of
4 arrow 101 into the hollow bore of the conduit 42 and
5 from there into the cap 200. The conduit 42 and the
6 cap 200 together form a flow diverter.

7
8 Tubing (not shown) is attached to output port 209 of
9 the cap 200 to divert the fluids to a remote
10 location for treatment such as quality analysis,
11 pressure boosting via a pump etc and thereafter
12 returned via tubing attached to the input port 208.
13 The treatment apparatus is normally provided on a
14 fixed or floating offshore installation.
15 To assemble the system, the cap 200 and LRP/EDP 300
16 are lowered into place from e.g. the rig or service
17 vessel and secured onto the top of the tree 100, as
18 shown in Fig. 2. LPMV 18, UPMV 17, PSV 15 and valve
19 207 are opened and PWV 12 is closed. The metal seal
20 (not shown) below the LPMV 18 is removed to the
21 surface from the production bore 1 via the cap 200
22 and LRP/EDP 300. The bores 1, 201, 301 are then
23 optionally filled with dense liquid, pressurised at
24 the surface to resist expulsion of production fluid,
25 and the conduit 42 is lowered from the surface to
26 the cap 200 on wireline.

27
28 The conduit 42 is inserted through the cap 200 and
29 secured into the production bore 201 of the cap 200
30 by any suitable means e.g. by wireline grooves,
31 threads or resilient teeth, and is also secured to
32 the production bore 1 of the tree 100 below PSV 15

1 and PWV 12 by inflatable or resilient seals 43 which
2 can seal the outside of the conduit 42 against the
3 inside walls of the production bore 1 to divert
4 production fluids flowing up the production bore in
5 the direction of arrow 101 into the hollow bore of
6 the conduit 42 and from there into the cap 200 as
7 shown in Fig. 3.

8

9 An advantage of the detachable conduit 42 is that
10 the cap 200 may be installed with the lower riser
11 package 300 (LRP) before removal of the full bore
12 plugs etc.. After removing these plugs through the
13 cap by conventional means the conduit 42 may be
14 attached as described herein. Thus the conduit 42
15 and cap 200 may be installed in a wide variety of
16 trees, regardless of whether there are plugs within
17 the bore or not. Typically a pressurised
18 installation system can be used in such cases. In
19 trees with no plugs, e.g. horizontal trees, the cap
20 is typically installed as part of the LRP and the
21 conduit may be inserted when required. This
22 obviates the need for retraction of the LRP etc to
23 attach the conduit, which would result in a pause in
24 fluid recovery and an associated loss in revenue.
25 With a pressurised installation tool the insert 42
26 can be installed and removed as necessary.

27

28 In use, the production fluids are recovered from the
29 production bore 1 and directed into the bore of the
30 conduit 42 as explained above. The fluids flow into
31 the cap 200 that optionally diverts them to a remote
32 surface test and clean up package to flare or

1 storage via the tubing (not shown). The fluids
2 (which may also be flow tested during well testing
3 at the surface) are then re-injected into the tree
4 via the branch 208, continue through the annulus
5 between the conduit 42 and the production bore 1 in
6 the direction of arrow 103 and thereafter through
7 the branch 10 to the pipeline (not shown).

8
9 Embodiments of the present invention therefore may
10 remove the need for onboard storage of hydrocarbons,
11 potentially eliminates flaring in wells when the
12 flowline is attached and can enable well testing
13 from a single hull DSV.

14
15 An alternative embodiment is shown in Fig 4. The
16 cap 200a has a large diameter conduit 42a extending
17 through the open PSV 15 and terminating in the
18 production bore 1 having seal stack 43a below the
19 branch 10, and a further seal stack 43b sealing the
20 bore of the conduit 42a to the inside of the
21 production bore 1 above the branch 10, leaving an
22 annulus between the conduit 42a and bore 1. Seals
23 43a and 43b are optionally disposed on an area of
24 the conduit 42a with reduced diameter in the region
25 of the branch 10. Seals 43a and 43b are also
26 disposed on either side of the crossover port 20
27 communicating via channel 21c to the crossover port
28 21 of the annulus bore 2. In the cap 200a, the
29 conduit 42a is closed by cap service valve (CSV) 204
30 which is normally open to allow flow of production
31 fluids from the production bore 1 via the central
32 bore of the conduit 42a through the outlet 209 to

1 the remote pump or chemical treatment apparatus.
2 The treated or pressurised production fluid is
3 returned from the remote pump or treatment apparatus
4 to the inlet of branch 210 which connects to the
5 annulus bore 202 in the cap 200 and is controlled by
6 cap flowline valve (CFV) 205. Annulus swab valve 32
7 is normally held open, annulus master valve 25 and
8 annulus wing valve 29 are normally closed, and
9 crossover valve 30 is normally open to allow
10 production fluids to pass through the annulus bore
11 2, then through the crossover channel 21c and
12 crossover port 20 between the seals 43a and 43b into
13 the annulus between the insert 42a and the
14 production bore 1, and thereafter through the open
15 PWV 12 into the bore of the outlet 10 for recovery
16 to the pipeline.

17
18 A crossover valve 212 is provided between the
19 production bore 201 and the annular bore 202 in
20 order to bypass the pump or treatment apparatus if
21 desired. Normally the crossover valve 212 is
22 maintained closed.

23
24 This embodiment maintains a fairly wide bore for
25 more efficient recovery of fluids at relatively high
26 pressure, thereby reducing pressure drops across the
27 apparatus.

28
29 This embodiment therefore provides a diverter
30 assembly for use with a wellhead tree comprising a
31 thin walled conduit with two seal stack elements,
32 connected to a tree cap, which straddles the

1 crossover valve outlet and flowline outlet (which
2 are approximately in the same horizontal plane),
3 diverting flow through the centre of the conduit and
4 the top of the tree cap to remote pressure boosting
5 or chemical treatment apparatus etc, with the return
6 flow routed via the tree cap and annulus bore (or
7 annulus flow path in concentric trees) and the
8 crossover loop and crossover outlet, to the annular
9 space between the straddle and the existing tree
10 bore through the wing valve to the flowline.

11

12 Like the previous embodiment, the insert 42a can be
13 inserted separately from the cap after the cap has
14 been attached, and can be secured by wireline
15 grooves etc and/or inflatable seals to the
16 production bore and/or the cap. However, this
17 embodiment can also be deployed from a local tool on
18 the tree without requiring the support of a MODU,
19 DSV, or RSV. The tool can carry the insert 42a and
20 can be deployed on top of the cap to install the
21 insert through the cap if desired.

22

23 A further, simpler embodiment is shown in Fig. 5
24 where the conduit 42a is replaced by a production
25 bore straddle 70 inserted after the attachment of
26 the cap in a similar manner to the insert 42 as
27 previously described, and having seals 73a and 73b
28 disposed on either side of a crossover port 20 but
29 which functions in a similar way as the Fig. 4
30 embodiment.

31

1 In use, the production fluids flow up the production
2 bore 1 through the bore of the straddle 70 and into
3 the cap 200 where they are optionally diverted via
4 outlets 208 or 209 to remote treatment or testing
5 apparatus as described for previous embodiments.
6 After suitable treatment the fluids are re-injected
7 into the annulus bore 2 of the tree 100 via the
8 inlet 210. Annulus swab valve 32 is normally held
9 open, with annulus master valve 25 and annulus wing
10 valve 29 normally closed, and crossover valve 30
11 normally open to allow production fluids to pass
12 through crossover channel 21c and crossover port 20
13 into the annulus between the straddle 70 and the
14 production bore 1 between the seals 43a and 43b, and
15 thereafter through the open PWV 12 into the
16 production outlet 10 for recovery to the pipeline.

17

18 This embodiment therefore provides a fluid diverter
19 for use with a wellhead tree which is not connected
20 to the tree cap by a thin walled conduit, but is
21 anchored in the tree bore, and which allows full
22 bore flow above the "straddle" portion, but routes
23 flow through the crossover and will allow a swab
24 valve (PSV) 15 to function normally. Again the
25 straddle can be fitted separately through the cap by
26 means of wireline etc.

27

28 The cap can be retrofitted to an existing tree cap
29 to use the hydraulic functionality of the existing
30 tree cap to enable additional valves to be
31 controlled, and provides a means to isolate the pump
32 from the production bore, if required. Certain

1 embodiments of the invention allow the device to be
2 installed/retro-fitted very cost effectively, with
3 no disruption to existing pipework and minimal
4 impact on control systems.

5

6 The cap can be used as part of the drilling riser
7 package to enable flow to be directed through the
8 surface test package, either choke manifold or
9 multiphase meter, and then into the flowline via the
10 tree. The cap is normally installed on top of the
11 tree and below the Lower Riser Package or the subsea
12 test tree, dependent on the tree configuration or as
13 extended tubing from the surface at the surface tree
14 or on coiled tubing or wireline or seal directly
15 against the bore of diverter unit.

16

17 A modified embodiment is shown in Fig 6, in which an
18 insert 42 inserted through the cap 200 into the
19 production bore 1 of a production tree 100 similar
20 to that shown in earlier figures, but in which the
21 insert 42 diverts the production fluids out through
22 the cap 200 into a remote booster pump or chemical
23 treatment device at the wellhead (not shown), and
24 back into the top of the annulus bore 2 of the tree.
25 The annulus swab valve 32 is closed off denying
26 passage of the production fluids through the
27 crossover as shown in the fig 4 and 5 embodiments,
28 but instead the cap crossover valve 212 is open
29 diverting the treated fluids from the wellhead back
30 into the annulus between the production bore 1 and
31 the insert 42, and thereafter out through the outlet
32 of the production bore and production wing valve 12.

1 This embodiment illustrates that different routes
2 can be selected through the cap with only surface
3 control by opening and closing valves in the tree or
4 cap using existing hydraulic connections.

5
6 Fig 7 shows a schematic view of a conventional
7 horizontal tree 100h with plugs P in the production
8 bore 1, a conventional tree cap C, and having no
9 valves above the production wing. Fig 8 shows an
10 embodiment of the invention adapted for use with
11 horizontal trees, having an insert 42b selectively
12 attached to a modified cap 200a as previously
13 described, and to the production bore 1 by seals 43
14 below the production wing outlet 10h. The cap 200a
15 can be installed as normal and the insert 42b can be
16 inserted from a pressurised tool or from surface if
17 the bore is pressurized or filled with dense fluid
18 to equalise the wellbore pressure during insertion.
19 The production bore plugs P can be withdrawn into
20 the insertion tool before the inserted is introduced
21 into the production bore, and sealed therein. After
22 insertion of the insert 42b the production fluids
23 are diverted into the cap 200a to a wellhead booster
24 or testing/treatment apparatus (not shown) and back
25 to the cap 200a, into the annulus between the
26 production bore 1 and the insert 42b, and thence to
27 the production wing outlet 10h.

28

29 The installation sequence of the fig 8 embodiment is
30 typically as follows:

31

1 The bores are first integrity tested from surface,
2 ensuring that there are no leaks in the system. The
3 cap C is then removed by a tree cap removal tool
4 lowered from surface, after the production and
5 annulus bores have been rigorously tested. After
6 removal of the conventional cap, the cap 22a
7 according to the invention is lowered from surface,
8 attached to the tree block, attached to the
9 hydraulic control lines of the previous tree cap and
10 tested. The cap 200a is maintained under
11 pressurised conditions and has a plug removal tool
12 that removes the plugs P from the production bore 1
13 while maintaining wellbore pressure in the tool.
14 After removal of the plugs P the insert 42b, which
15 is typically carried on the outboard end of the cap
16 200a or by a separate installation tool landed on
17 the cap 200a, is then stroked into the production
18 bore 1 and sealed to the cap 200a and the production
19 bore below the production wing outlet 10h. The
20 insert swab valve is then opened and the system
21 again tested for pressure integrity. A pump can
22 then be lowered to the wellhead and attached locally
23 to the top of the cap 200a or can be run from
24 surface as required. Thereafter, the production
25 fluids are then diverted from the production bore
26 through the bore of the insert 42b, into the cap
27 200a, through the pump and back into the annulus
28 between the insert 42 and the production bore 1 as
29 previously described, before being recovered as
30 normal from the outlet 10h of the production wing.
31

1 The above embodiment can be deployed from a local
2 tool landed on the tree and therefore can dispense
3 with the requirement for support from a MODU, DSV or
4 RSV, with associated cost savings. The fig 8
5 embodiment can be used for horizontal and vertical
6 trees, and is typically deployed with a pressurised
7 tool to remove the plugs and install the insert.

8

9 The pump can be substituted for a chemical injection
10 apparatus, and the insert can be attached entirely
11 to the production bore rather than to the cap 200a.

12

13 Certain embodiments of the invention may be most
14 readily utilised on remote subsea production wells
15 in normal mode or during well testing, although
16 other embodiments may be used on sub sea water
17 injection wells, land based oil production and
18 injection wells and possibly geothermal wells. A
19 pump may be connected to the head and powered by
20 high-pressure water or electricity, which could be
21 supplied directly from a fixed or floating offshore
22 installation, or from a tethered buoy arrangement or
23 by high-pressure gas from a local source for
24 example.

25

26 Modifications and improvements may be made without
27 departing from the scope of the invention.

1 Claims

2

3 1. A flow diverter assembly for a tree, the flow
4 diverter assembly having a flow diverter to
5 divert fluids flowing through the production
6 bore of the tree from a first portion of the
7 production bore to the cap, and to divert the
8 fluids back from the cap to a second portion of
9 the production bore for recovery therefrom via
10 an outlet, wherein the flow diverter is
11 detachable from the cap to enable insertion of
12 the flow diverter through the cap.

13

14 2. An assembly as claimed in claim 1, wherein the
15 tree is a subsea tree.

16

17 3. An assembly as claimed in claim 1 or claim 2,
18 wherein the flow diverter comprises a conduit
19 inserted into the production bore.

20

21 4. An assembly as claimed in claim 3, having
22 sealing means capable of sealing the conduit
23 against the wall of the production bore.

24

25 5. An assembly as claimed in claim 3 or claim 4,
26 wherein the conduit provides a first flowpath
27 through a bore thereof, and a second flowpath
28 in the annulus between the conduit and the
29 production bore.

30

31 6. An assembly as claimed in any preceding claim
32 wherein the flow diverter can be withdrawn

1 through the cap without detaching the cap from
2 the tree.

3

4 7. A method of installing a flow diverter on a
5 tree, the method comprising attaching a cap to
6 the tree, and installing the diverter through
7 the cap after the cap has been attached to the
8 tree.

9

10 8. A method as claimed in claim 7, wherein the
11 diverter is carried by the cap.

12

13 9. A method as claimed in claim 7 or claim 8,
14 wherein the flow diverter is installed from a
15 local installation device.

16

17 10. A method of recovering production fluids from a
18 well having a tree, the tree having a first
19 flowpath and a second flowpath, the method
20 comprising diverting fluids from a first
21 portion of the first flowpath to the second
22 flowpath, and diverting the fluids from the
23 second flowpath back to a second portion of the
24 first flowpath, and thereafter recovering
25 fluids from the outlet of the first flowpath,
26 wherein the fluids are diverted from the
27 wellhead to a remote location, and are returned
28 to the wellhead from the remote location for
29 diversion into the outlet of the first
30 flowpath.

31

1 11. A method as claimed in claim 10, wherein the
2 first flowpath is a production bore.

3
4 12. A method as claimed in claim 10 or claim 11,
5 wherein the second flowpath is an annulus bore
6 of the tree, or an annulus between a conduit
7 inserted into the first flowpath and the bore
8 of the first flowpath.

9
10 13. A method as claimed in any one of claims 10-12,
11 wherein the flow diversion from the first
12 flowpath to the second flowpath is achieved by
13 a cap on the tree.

14
15 14. A method for recovering fluids from a well
16 having a tree, the tree having a cap and a
17 first flowpath and a second flowpath, the
18 method comprising attaching the cap to the
19 tree, inserting a fluid diverter to divert
20 fluids from a bore of the tree to a second
21 flowpath, diverting fluids from the second
22 flowpath back to a second portion of the bore,
23 and thereafter recovering fluids from the
24 outlet of the bore wherein the first or second
25 flowpath is attached to or detached from the
26 cap without detaching the cap from the tree.

27
28 15. A method as claimed in claim 14, including the
29 steps of withdrawing a plug from the bore of
30 the tree after the cap has been attached, and
31 thereafter inserting the fluid diverter into
32 the bore of the tree.

1

2 16. A method as claimed in claim 14 or claim 15,
3 wherein the diverter comprises a tubular or
4 other conduit inserted into the bore of the
5 tree.

6

7 17. A method as claimed in any one of claims 14-16,
8 including the steps of removing a plug from the
9 bore before the flow diverter is inserted.

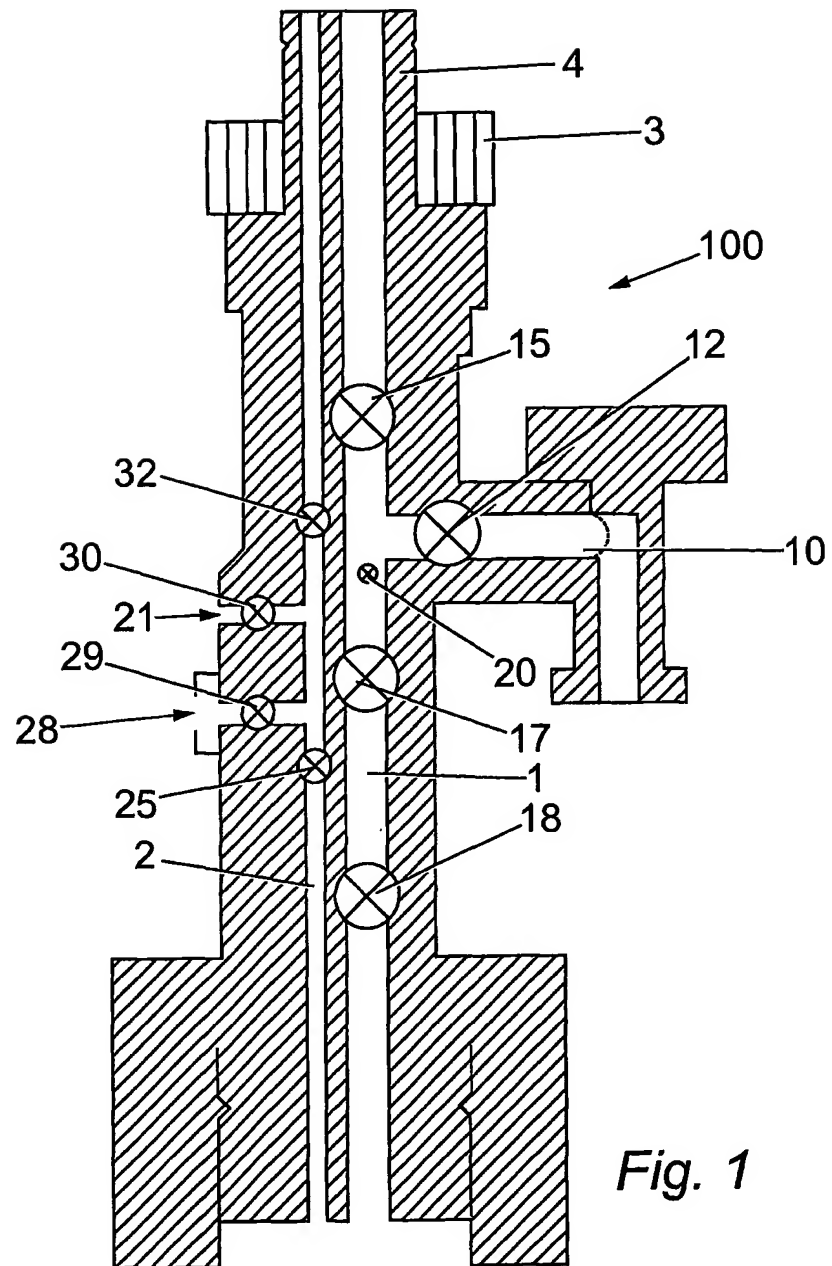
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11 18. A method as claimed in any one of claims 14-17,
12 wherein the flow diverter is inserted by
13 wireline.

14

15 19. A method as claimed in any one of claims 14-17,
16 wherein the flow diverter is inserted by a
17 local installation device.

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2 / 8

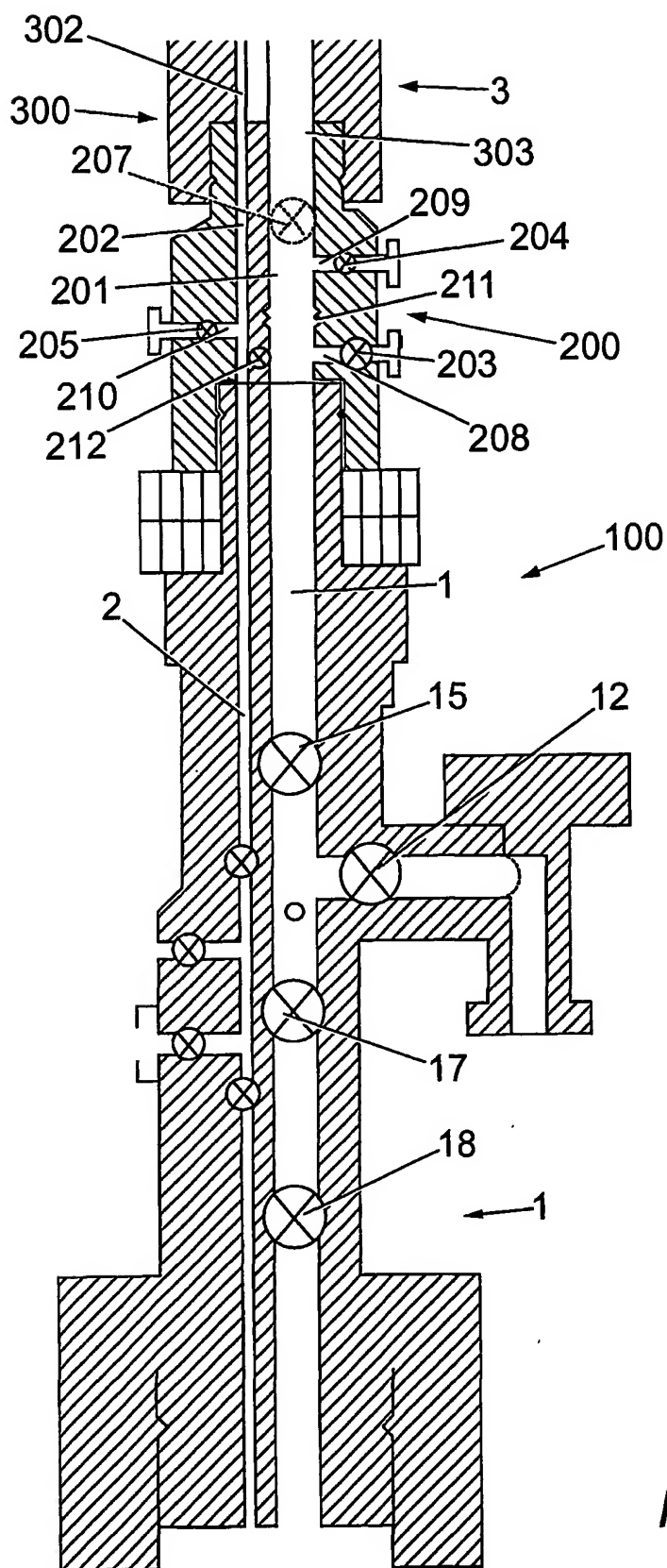


Fig. 2a

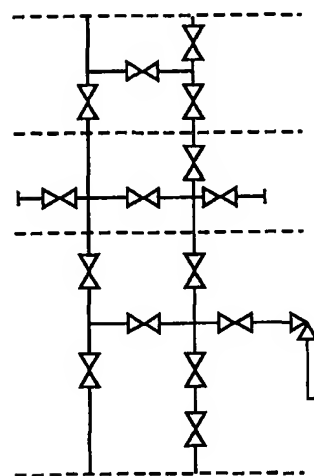


Fig. 2b

3 / 8

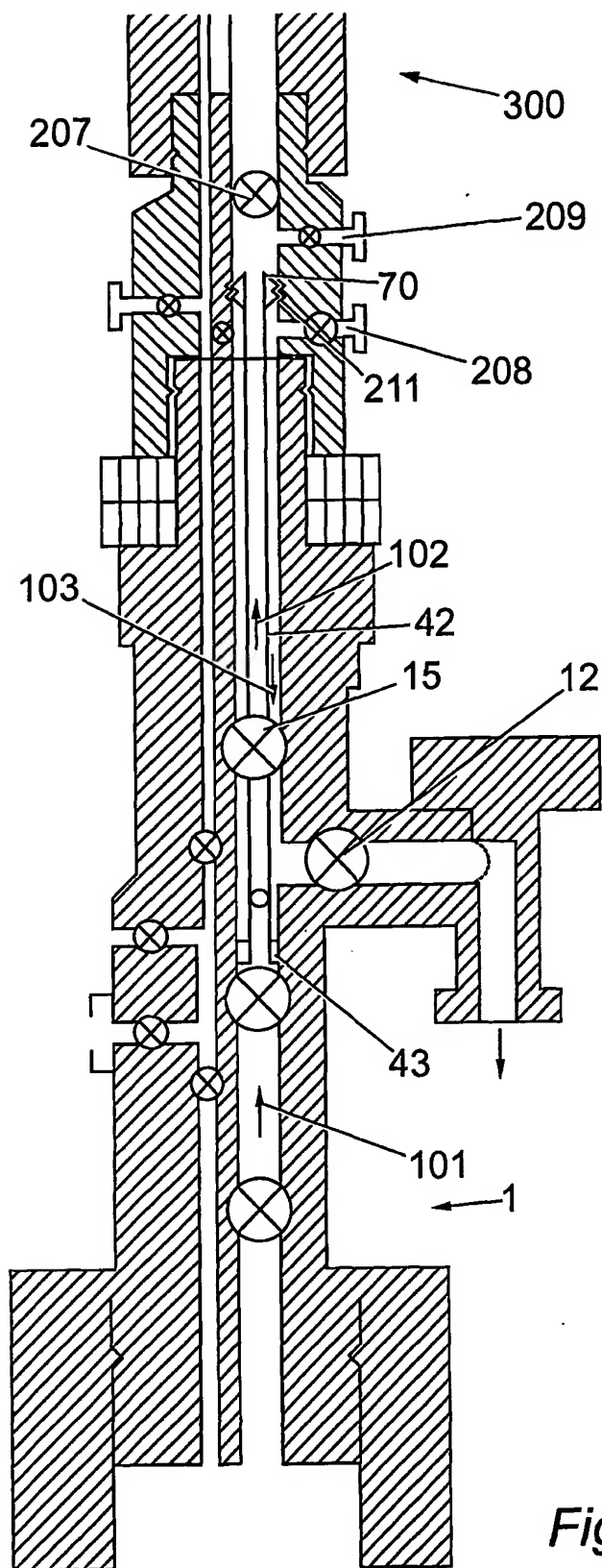


Fig. 3a

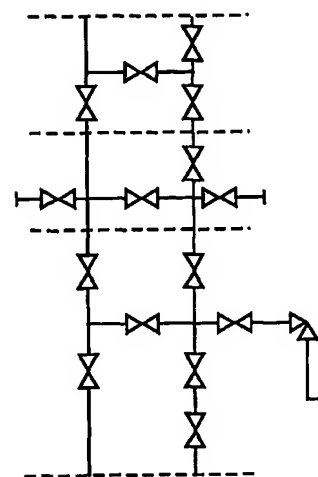


Fig. 3b

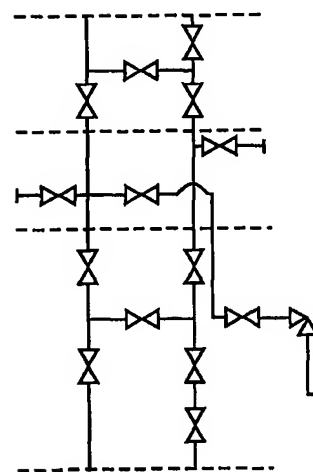


Fig. 3c

4 / 8

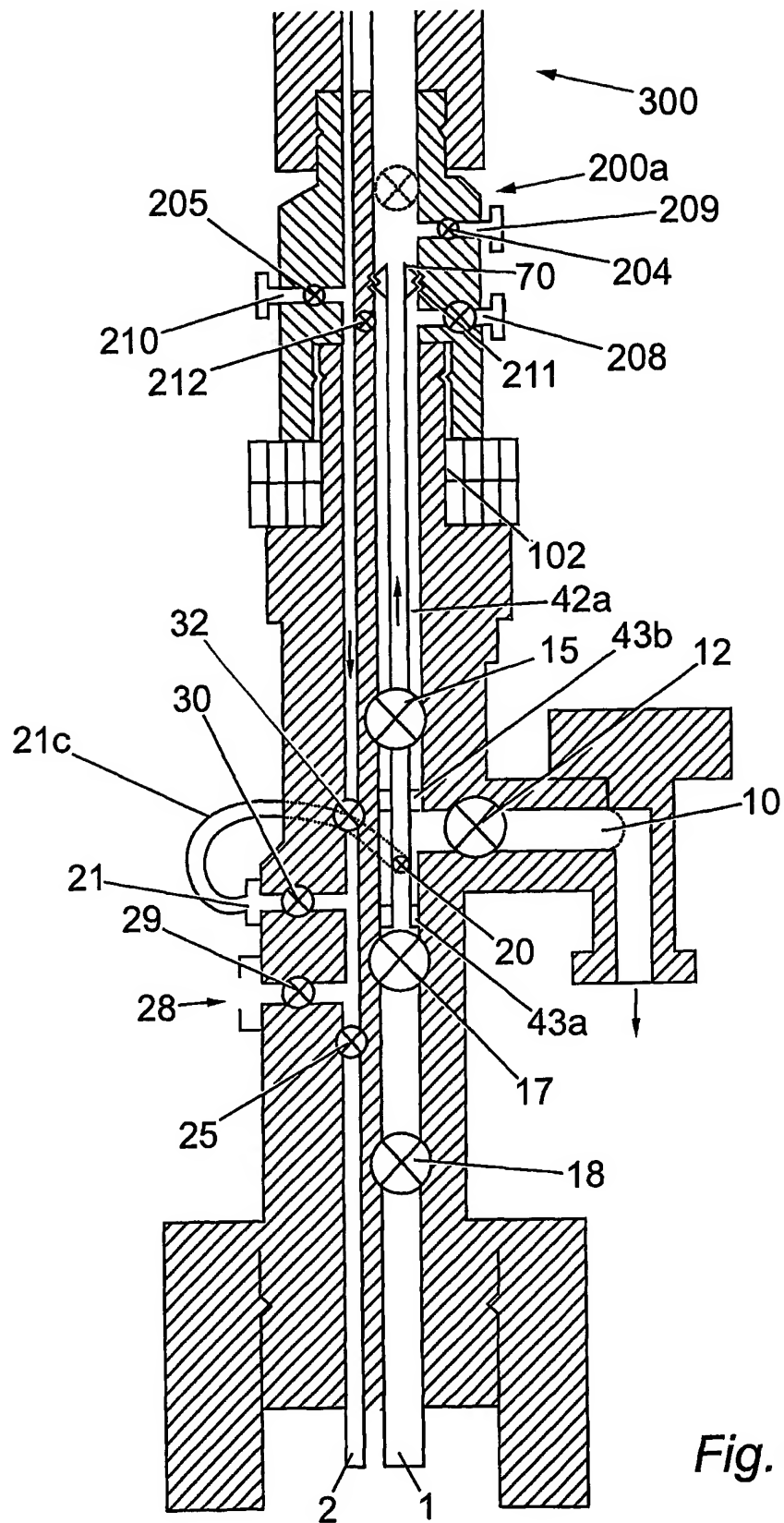
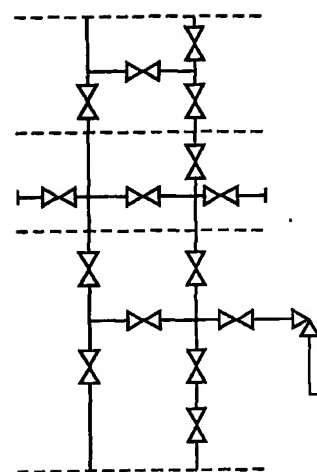
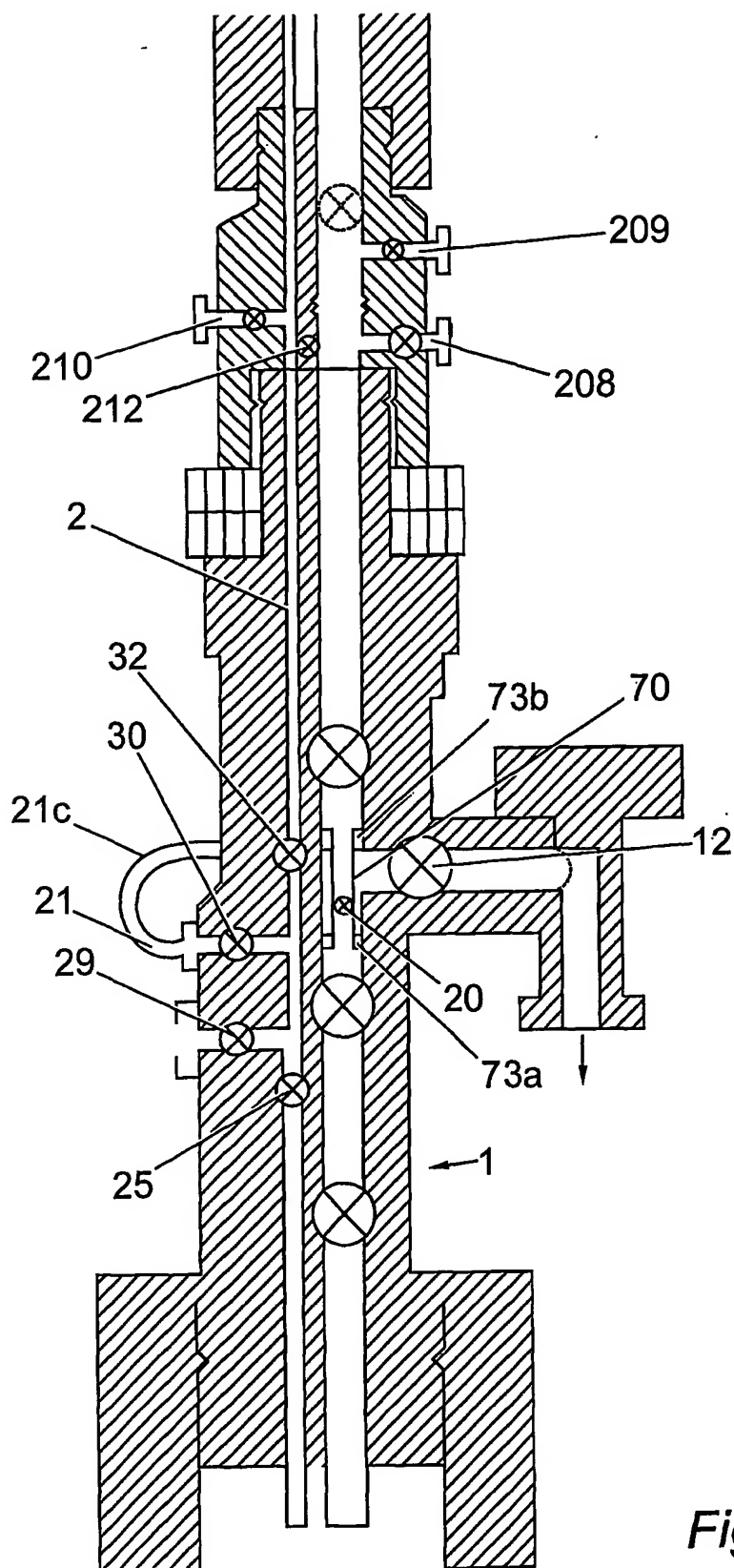


Fig. 4

5/8

*Fig. 5b**Fig. 5a*

6 / 8

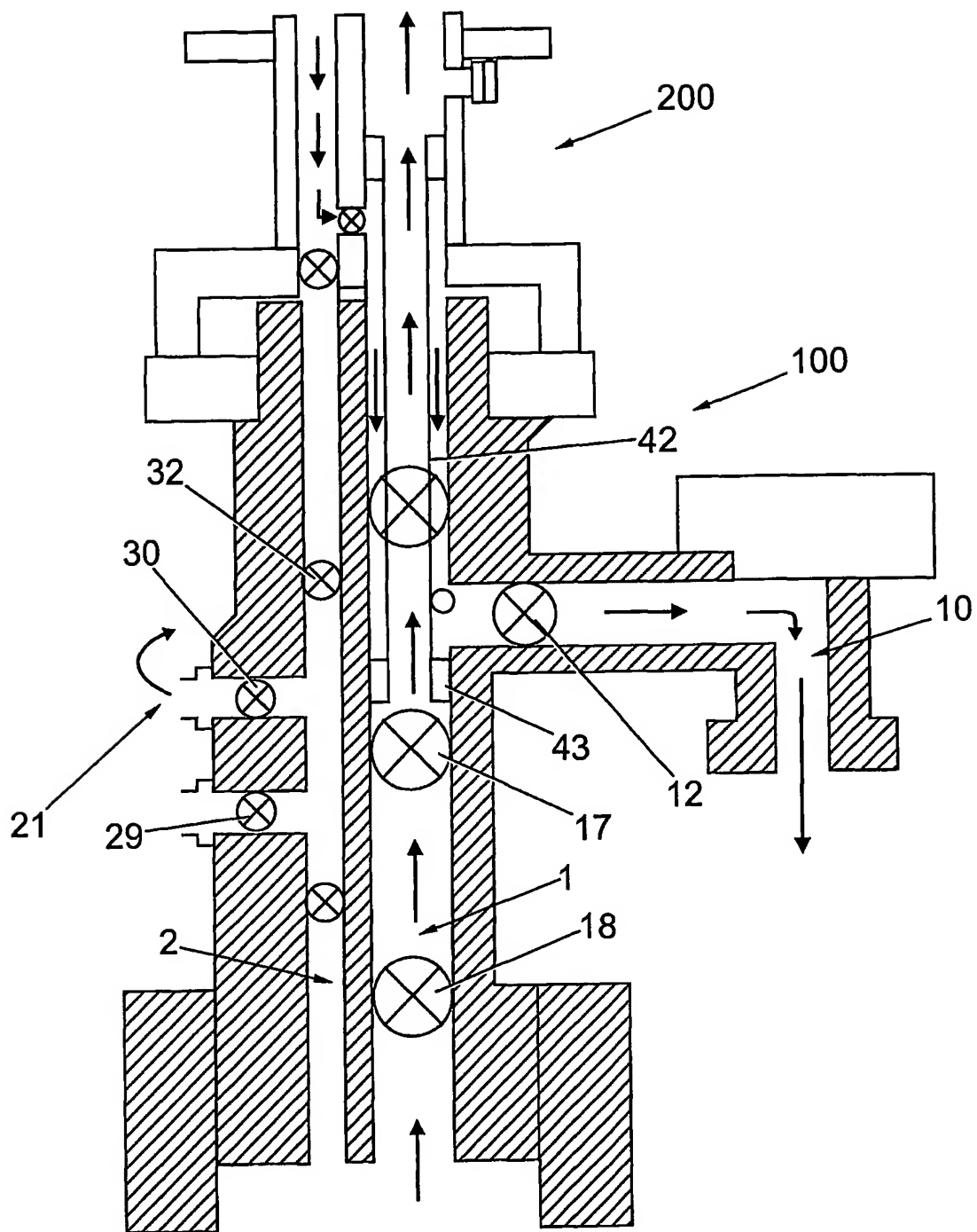
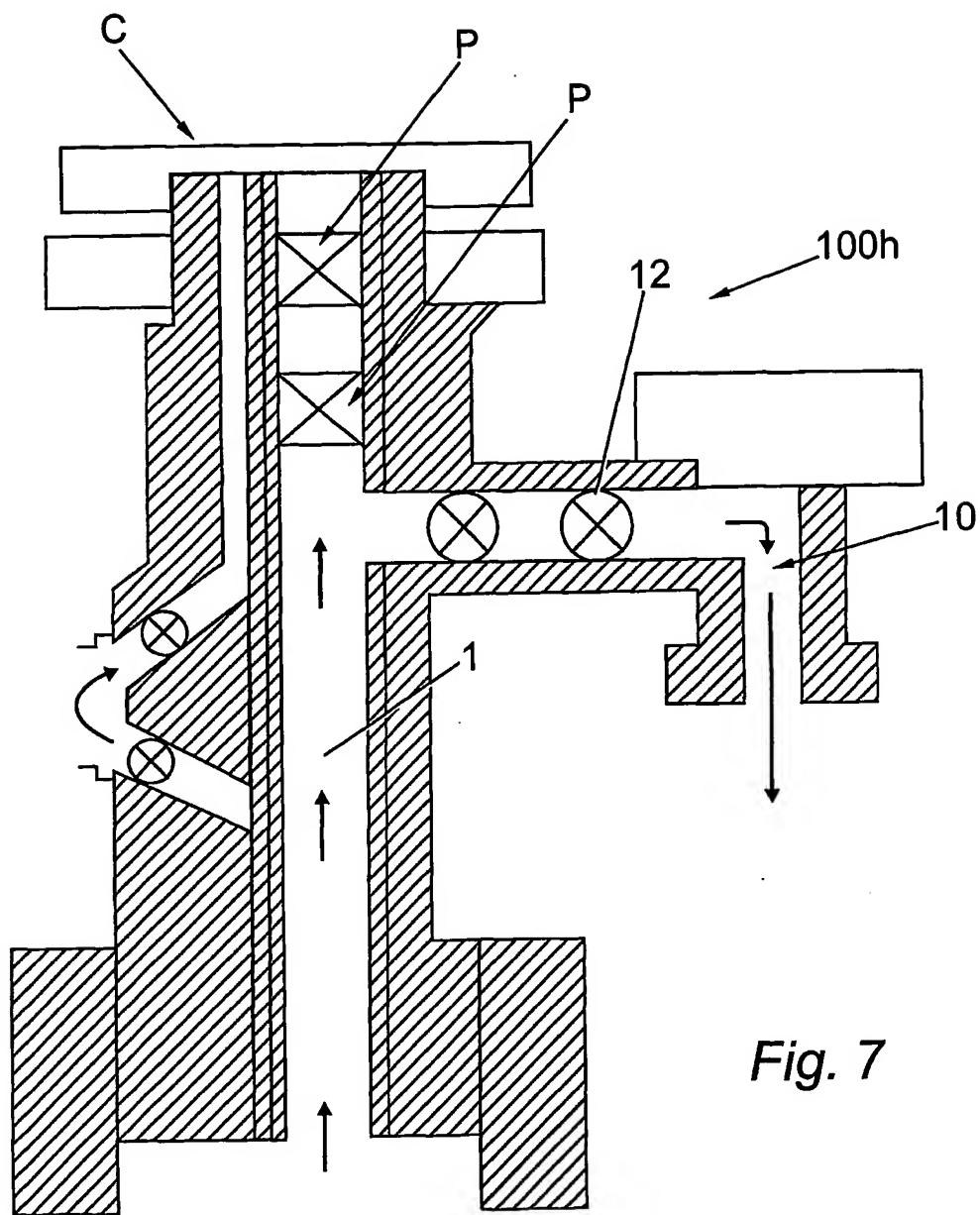


Fig. 6

7 / 8



8 / 8

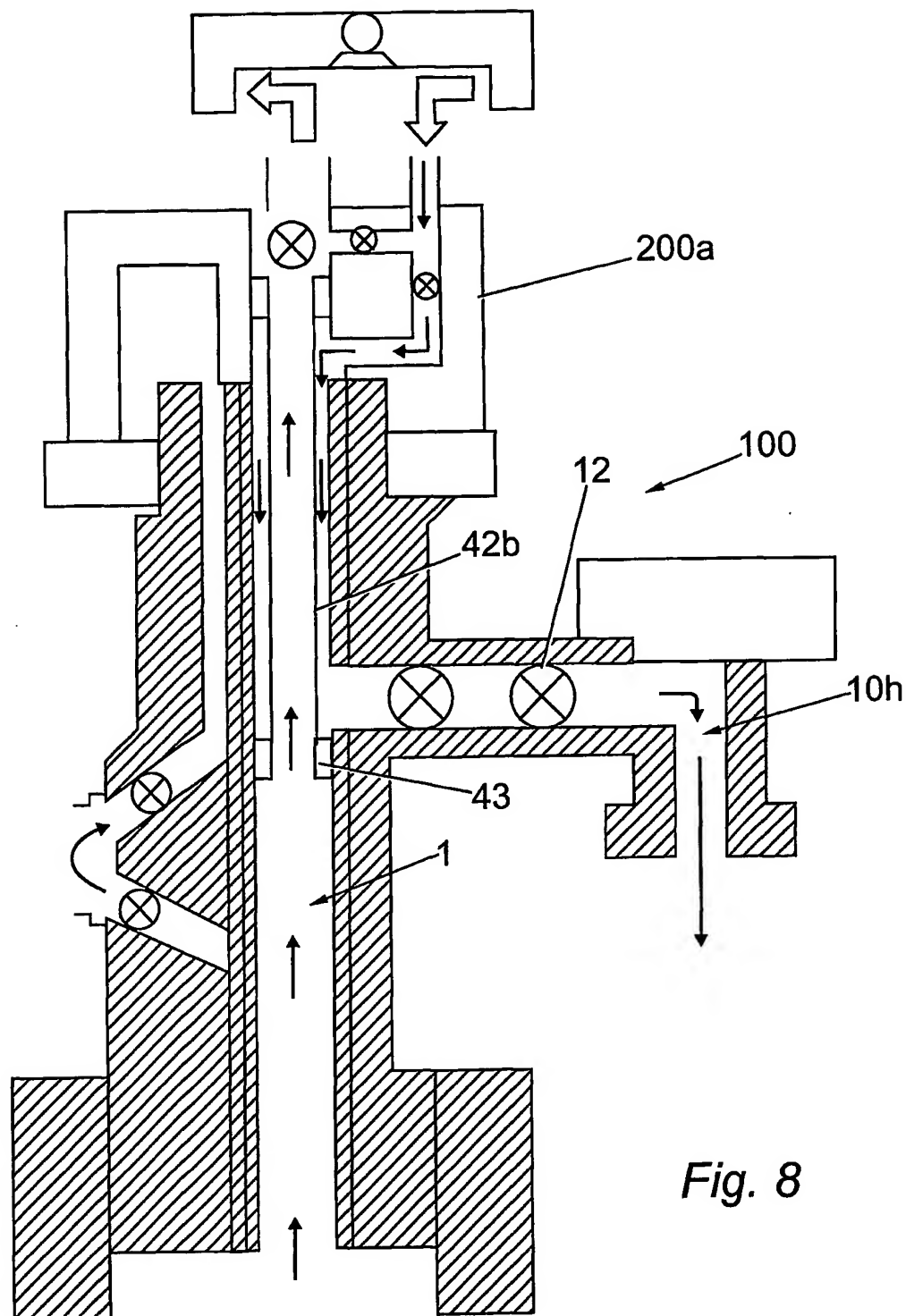


Fig. 8

INTERNATIONAL SEARCH REPORT

PCT/GB 01/04940

A. CLASSIFICATION OF SUBJECT MATTER IPC 7 E21B33/035 E21B34/04 E21B33/076		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 7 E21B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the International search (name of data base and, where practical, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO 00 70185 A (ENHANCED RECOVERY LTD DES ;DONALD IAN (GB); STEELE JAMES (GB)) 23 November 2000 (2000-11-23) cited in the application the whole document	1-19
A	GB 2 319 795 A (VETCO GRAY INC ABB) 3 June 1998 (1998-06-03) page 5, line 4 - line 6 page 7, line 15 -page 8, line 4; figures 1,2	1-19
P,A	GB 2 361 726 A (FMC CORP) 31 October 2001 (2001-10-31) page 4, line 29 -page 5, line 4 -/--	1-19
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents : *A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art *&* document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
25 February 2002		04/03/2002
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3018		Authorized officer Garrido Garcia, M

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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